

Claims

1. A color compensation method of receiving video frame data from a camera outside a vehicle and automatically compensating for colors of the video frame data for a person with anomalous trichromacy in the vehicle, comprising the steps of:

extracting digital video frame data from a digital observation camera;

calculating external environment conditions from the extracted video frame data;

receiving color blindness characteristics of a color-blind driver;

receiving preference of the color-blind driver;

compensating for colors of the video frame data according to the external environment conditions and the input information; and

displaying finally compensated colors according to the preference of the color-blind driver.

2. The method according to claim 1, wherein the step of calculating the external environment conditions is performed in such a way that brightness and colors of external environment are extracted from the video frame data and transmitted to a color compensation unit.

3. The method according to claim 1, wherein the step of receiving the color blindness characteristics is performed in such a way as to receive a type and degree of the color blindness and display the type of the color blindness, and degrees of abnormality of cone cells related to colors are expressed using functions p and q as follows:
 5 in the case of Red blindness,

$$L_R^{color\ blindness} = \int p(d_R)L(\lambda - q(d_R))R(\lambda)d\lambda$$

$$L_G^{color\ blindness} = \int p(d_R)L(\lambda - q(d_R))G(\lambda)d\lambda$$

$$10 \quad L_B^{color\ blindness} = \int p(d_R)L(\lambda - q(d_R))B(\lambda)d\lambda$$

in the case of Green blindness,

$$M_R^{color\ blindness} = \int p(d_G)M(\lambda - q(d_G))R(\lambda)d\lambda$$

$$M_G^{color\ blindness} = \int p(d_G)M(\lambda - q(d_G))G(\lambda)d\lambda$$

$$M_B^{color\ blindness} = \int p(d_G)M(\lambda - q(d_G))B(\lambda)d\lambda$$

15 in the case of Blue blindness,

$$S_R^{color\ blindness} = \int p(d_B)S(\lambda - q(d_B))R(\lambda)d\lambda$$

$$S_G^{color\ blindness} = \int p(d_B)S(\lambda - q(d_B))G(\lambda)d\lambda$$

$$S_B^{color\ blindness} = \int p(d_B)S(\lambda - q(d_B))B(\lambda)d\lambda$$

4. The method according to claim 1, wherein the step of receiving the preference of the driver comprises the steps of:
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quantizing a range of colors preferred by the color-blind driver and setting the range to enable the driver to clearly distinguish different colors;

5 magnifying a part of an object desired to be shown in detail by the driver when the driver desires to sense colors of traffic lights or external environment; and

reading the colors of the corresponding object, changing the colors to characters, and representing the characters in a voice form using a Text-To-Speech (TTS) technology.

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5. The method according to claim 2, wherein the extraction of the brightness and the colors of the external environment is performed in such a way that a portion of the video frame screen is set to a reference image piece and the external brightness and colors are measured from the reference image.

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6. The method according to claim 5, wherein the step of compensating for colors using the reference image piece is performed in such a way that a color tone is calibrated using a difference between reference brightness and colors that are previously measured from the reference image piece and stored in a daylight condition, and the external brightness and colors calculated at the step of calculating the external environment.

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7. The method according to claim 1, wherein:

the step of compensating for colors of the video frame data comprises all the steps of compensating for colors depending on the input external environment conditions, compensating for colors that is performed by compensating RGB colors of the extracted video frame data according to a color range of user preference, and compensating for colors depending on the input color blindness characteristics of the driver; and

10 wherein, in the case of dichromacy, the step of compensating for colors is applied, with a small specific constant numbers other than zero being set instead of an L, M or S value;

15 wherein the step of compensating for colors is performed using one of the following equations, in the case of Red blindness,

$$\begin{bmatrix} R4(x, y) \\ G4(x, y) \\ B4(x, y) \\ 1 \end{bmatrix} = \begin{bmatrix} L_R^{color\ blindness} & L_G^{color\ blindness} & L_B^{color\ blindness} & 0 \\ M_R & M_G & M_B & 0 \\ S_R & S_G & S_B & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}^{-1} \times \begin{bmatrix} L_R & L_G & L_B & 0 \\ M_R & M_G & M_B & 0 \\ S_R & S_G & S_B & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times$$

$$\text{round} \left\{ \begin{bmatrix} 1 & 0 & 0 & 0 \\ \frac{1}{Qstep_R} & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & \Delta R(x, y) \\ 0 & 1 & 0 & \Delta G(x, y) \\ 0 & 0 & 1 & \Delta B(x, y) \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} \frac{W}{W(x, y)} \frac{\text{reference bright}}{W(x, y)} & 0 & 0 & 0 \\ 0 & \frac{W}{W(x, y)} \frac{\text{reference bright}}{W(x, y)} & 0 & 0 \\ 0 & 0 & \frac{W}{W(x, y)} \frac{\text{reference bright}}{W(x, y)} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} R(x, y) \\ G(x, y) \\ B(x, y) \\ 1 \end{bmatrix} \right\}$$

in the case of Green blindness,

$$\begin{bmatrix} R4(x,y) \\ G4(x,y) \\ B4(x,y) \\ 1 \end{bmatrix} = \begin{bmatrix} L_R & L_G & L_B & 0 \\ M_R^{color\ blindness} & M_G^{color\ blindness} & M_B^{color\ blindness} & 0 \\ S_R & S_G & S_B & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}^{-1} \times \begin{bmatrix} L_R & L_G & L_B & 0 \\ M_R & M_G & M_B & 0 \\ S_R & S_G & S_B & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times$$

$$\text{round} \left\{ \begin{bmatrix} \frac{1}{Qstep_R} & 0 & 0 & 0 \\ 0 & \frac{1}{Qstep_G} & 0 & 0 \\ 0 & 0 & \frac{1}{Qstep_B} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & \Delta R(x,y) \\ 0 & 1 & 0 & \Delta G(x,y) \\ 0 & 0 & 1 & \Delta B(x,y) \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} \frac{W}{W(x,y)} \frac{reference\ brightness}{W(x,y)} & 0 & 0 & 0 \\ 0 & \frac{W}{W(x,y)} \frac{reference\ brightness}{W(x,y)} & 0 & 0 \\ 0 & 0 & \frac{W}{W(x,y)} \frac{reference\ brightness}{W(x,y)} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} R(x,y) \\ G(x,y) \\ B(x,y) \\ 1 \end{bmatrix} \right\}$$

in the case of Blue blindness,

$$\begin{bmatrix} R4(x,y) \\ G4(x,y) \\ B4(x,y) \\ 1 \end{bmatrix} = \begin{bmatrix} L_R & L_G & L_B & 0 \\ M_R & M_G & M_B & 0 \\ S_R^{color\ blindness} & S_G^{color\ blindness} & S_B^{color\ blindness} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}^{-1} \times \begin{bmatrix} L_R & L_G & L_B & 0 \\ M_R & M_G & M_B & 0 \\ S_R & S_G & S_B & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times$$

$$\text{round} \left\{ \begin{bmatrix} \frac{1}{Qstep_R} & 0 & 0 & 0 \\ 0 & \frac{1}{Qstep_G} & 0 & 0 \\ 0 & 0 & \frac{1}{Qstep_B} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & \Delta R(x,y) \\ 0 & 1 & 0 & \Delta G(x,y) \\ 0 & 0 & 1 & \Delta B(x,y) \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} \frac{W}{W(x,y)} \frac{reference\ brightness}{W(x,y)} & 0 & 0 & 0 \\ 0 & \frac{W}{W(x,y)} \frac{reference\ brightness}{W(x,y)} & 0 & 0 \\ 0 & 0 & \frac{W}{W(x,y)} \frac{reference\ brightness}{W(x,y)} & 0 \\ 0 & 0 & 0 & \frac{W}{W(x,y)} \frac{reference\ brightness}{W(x,y)} \end{bmatrix} \times \begin{bmatrix} R(x,y) \\ G(x,y) \\ B(x,y) \\ 1 \end{bmatrix} \right\}$$

8. A color compensation system for receiving video frame data by a camera outside a vehicle and automatically compensating for colors of the video frame data for a person

with anomalous trichromacy in the vehicle, comprising:

means for extracting digital video frame data input to a digital observation camera;

means for calculating external environment conditions from the extracted video frame data;

5 means for receiving color blindness characteristics of a color-blind driver;

means for receiving preference of the color-blind driver;

10 means for compensating for colors of the video frame data according to the external environment conditions and input information; and

means for displaying finally compensated colors according to the preference of the color-blind driver.

9. The color compensation system according to claim 15 8, wherein the means for calculating the external environment conditions extracts brightness and colors of the external environment from the extracted video frame data and transmits the brightness and colors to a color compensation unit.

20 10. The color compensation system according to claim 8, wherein the means for receiving the color blindness characteristics receives a type and degree of the color blindness and displays the type of the color blindness, and

displays degrees of abnormality of cone cells related to colors using functions p and q as follows:

in the case of Red blindness,

$$L_R^{color\ blindness} = \int p(d_R) L(\lambda - q(d_R)) R(\lambda) d\lambda$$

$$5 \quad L_G^{color\ blindness} = \int p(d_R) L(\lambda - q(d_R)) G(\lambda) d\lambda$$

$$L_B^{color\ blindness} = \int p(d_R) L(\lambda - q(d_R)) B(\lambda) d\lambda$$

in the case of Green blindness,

$$M_R^{color\ blindness} = \int p(d_G) M(\lambda - q(d_G)) R(\lambda) d\lambda$$

$$M_G^{color\ blindness} = \int p(d_G) M(\lambda - q(d_G)) G(\lambda) d\lambda$$

$$10 \quad M_B^{color\ blindness} = \int p(d_G) M(\lambda - q(d_G)) B(\lambda) d\lambda$$

in the case of Blue blindness,

$$S_R^{color\ blindness} = \int p(d_B) S(\lambda - q(d_B)) R(\lambda) d\lambda$$

$$S_G^{color\ blindness} = \int p(d_B) S(\lambda - q(d_B)) G(\lambda) d\lambda$$

$$S_B^{color\ blindness} = \int p(d_B) S(\lambda - q(d_B)) B(\lambda) d\lambda$$

15 11. The color compensation system according to claim 8, wherein the means for receiving the preference of the driver comprises:

means for quantizing a range of colors preferred by the color-blind driver and setting the range to enable the driver to clearly distinguish different colors;

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means for magnifying a part of an object desired to

be shown in detail by the driver when the driver desires to sense colors of traffic lights or external environment; and

means for reading the colors of the corresponding object, changing the colors to characters, and displaying
5 the characters in a voice form using a TTS technology.

12. The color compensation system according to claim 9, wherein the means for extracting the brightness and colors of the external environment sets a portion of the video frame screen to a reference image piece, and measures
10 the external brightness and colors from the reference image.

13. The color compensation system according to claim 8, wherein the means for compensating for the colors of the video frame data comprises all means for compensating for
15 colors depending on the measured external environment conditions, compensating for colors that is performed by compensating for RGB colors of the extracted video frame data according to a color range of user preference, and compensating for colors depending on the input color
20 blindness characteristics of the driver; and

wherein, in the case of dichromacy, the step of compensating for colors is applied, with a small specific constant numbers other than zero being set instead of an L, M or S value;

wherein the step of compensating for colors is performed using one of the following equations, in the case of Red blindness,

$$\begin{aligned}
 \begin{bmatrix} R4(x,y) \\ G4(x,y) \\ B4(x,y) \\ 1 \end{bmatrix} &= \begin{bmatrix} L_R^{color\ blindness} & L_G^{color\ blindness} & L_B^{color\ blindness} & 0 \\ M_R & M_G & M_B & 0 \\ S_R & S_G & S_B & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}^{-1} \times \begin{bmatrix} L_R & L_G & L_B & 0 \\ M_R & M_G & M_B & 0 \\ S_R & S_G & S_B & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \\
 5 \quad round \left(\begin{bmatrix} \frac{1}{Qstep_R} & 0 & 0 & 0 \\ 0 & \frac{1}{Qstep_G} & 0 & 0 \\ 0 & 0 & \frac{1}{Qstep_B} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & \Delta R(x,y) \\ 0 & 1 & 0 & \Delta G(x,y) \\ 0 & 0 & 1 & \Delta B(x,y) \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} \frac{W}{reference\ brightness} & 0 & 0 & 0 \\ 0 & \frac{W}{reference\ brightness} & 0 & 0 \\ 0 & 0 & \frac{W}{reference\ brightness} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} R(x,y) \\ G(x,y) \\ B(x,y) \\ 1 \end{bmatrix} \right)
 \end{aligned}$$

in the case of Green blindness,

$$\begin{aligned}
 \begin{bmatrix} R4(x,y) \\ G4(x,y) \\ B4(x,y) \\ 1 \end{bmatrix} &= \begin{bmatrix} L_R & L_G & L_B & 0 \\ M_R^{color\ blindness} & M_G^{color\ blindness} & M_B^{color\ blindness} & 0 \\ S_R & S_G & S_B & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}^{-1} \times \begin{bmatrix} L_R & L_G & L_B & 0 \\ M_R & M_G & M_B & 0 \\ S_R & S_G & S_B & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \\
 round \left(\begin{bmatrix} \frac{1}{Qstep_R} & 0 & 0 & 0 \\ 0 & \frac{1}{Qstep_G} & 0 & 0 \\ 0 & 0 & \frac{1}{Qstep_B} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & \Delta R(x,y) \\ 0 & 1 & 0 & \Delta G(x,y) \\ 0 & 0 & 1 & \Delta B(x,y) \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} \frac{W}{reference\ brightness} & 0 & 0 & 0 \\ 0 & \frac{W}{reference\ brightness} & 0 & 0 \\ 0 & 0 & \frac{W}{reference\ brightness} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} R(x,y) \\ G(x,y) \\ B(x,y) \\ 1 \end{bmatrix} \right)
 \end{aligned}$$

in the case of Blue blindness,

$$\begin{bmatrix} R4(x,y) \\ G4(x,y) \\ B4(x,y) \\ 1 \end{bmatrix} = \begin{bmatrix} L_R & L_G & L_B & 0 \\ M_R & M_G & M_B & 0 \\ S_R^{color\ blindness} & S_G^{color\ blindness} & S_B^{color\ blindness} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}^{-1} \times \begin{bmatrix} L_R & L_G & L_B & 0 \\ M_R & M_G & M_B & 0 \\ S_R & S_G & S_B & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times$$

$$round \left[\begin{bmatrix} \frac{1}{Qstep_R} & 0 & 0 & 0 \\ 0 & \frac{1}{Qstep_G} & 0 & 0 \\ 0 & 0 & \frac{1}{Qstep_B} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & \Delta R(x,y) \\ 0 & 1 & 0 & \Delta G(x,y) \\ 0 & 0 & 1 & \Delta B(x,y) \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} \frac{W_{reference\ brightness}}{W(x,y)} & 0 & 0 & 0 \\ 0 & \frac{W_{reference\ brightness}}{W(x,y)} & 0 & 0 \\ 0 & 0 & \frac{W_{reference\ brightness}}{W(x,y)} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} R(x,y) \\ G(x,y) \\ B(x,y) \\ 1 \end{bmatrix} \right]$$

14. A color observation system for vehicles connected to an external camera, comprising:

5 means for compensating for colors of video frame data input from an observation camera in view of external brightness and colors;

means for compensating for colors in view of color blindness characteristics of a color-blind driver;

10 means for compensating for colors according to preference of the color-blind driver; and

means for receiving color information of external objects through a monitor or speaker according to user preference.